Experimental study on safety distance for pedestrians under different interaction angles

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Abstract Pedestrians must adjust their motion behaviors to avoid collisions with other moving objects in real-world scenarios. Here, a series of pedestrian interaction experiments were conducted to investigate the safety distance maintained during collision avoidance across various interaction angles. The results demonstrated that the safety distance between pedestrians decreased from 2.31 m to 0.95 m as the interaction angles decreased from 150° to 30° (increments of 30°). This finding provides a valuable empirical foundation for advancing research on collision avoidance algorithms.

Keywords collision avoidance, pedestrian interactions, safety distance

Instruction

In recent years, new devices such as self-driving cars and service robots have appeared in people's daily lives. They have embedded motion models to plan their routes and avoid collisions with other objects [1–3], which include social force models [4,5], cellular automata models [6], behavioral heuristics models [7], etc. These models have shown promising prospects and results in current device navigation [3] and crowd simulation [8]. However, shortcomings of the models also exist, such as lower validity and a lack of accuracy, which might result in misprediction and collision accidents. Therefore, studying the collision avoidance behavior of moving objects, especially pedestrians, is essential for more accurate modified motion models.

In this study, we conducted well-controlled experiments on interacting pedestrians. The optical motion capture system directly tracked the alternating movement of the two legs of each pedestrian, enabling a full investigation of the collision avoidance process of interacting pedestrians. The effects of step length and different interaction angles were examined. In the future, the decision-making process and basis of pedestrians in the collision avoidance process will be systematically analyzed.

We recruited 16 participants (10 males and 6 females) from Tsinghua University. The age range of all participants was 18-24. The height was 1.7 $\pm$ 0.1 m, and the BMI was within the normal range.

As shown in Figure 1a, the experimental measurement area was a circular area with a radius of 5 m with the intersection point of the two planned participants' routes as the center. Twelve equally spaced labels were placed on the boundary of the circular measuring area in the field so that the subjects knew their starting and ending positions. We took Figure 1b as the diagram and took black and green pedestrians as examples to further illustrate the experimental process. The green and black pedestrians were assumed to be participants A and B. The green and black lines were the motion routes of A and B. The red center of the circle was the intersection of green and black lines. The other blue lines were the planned walking routes assigned to the subjects according to the experimental needs of different interaction angles. The numbers on the periphery of the circular area are designed to help pedestrians understand their starting and target positions in the experiment. Different experimental routes represent different interaction angles.

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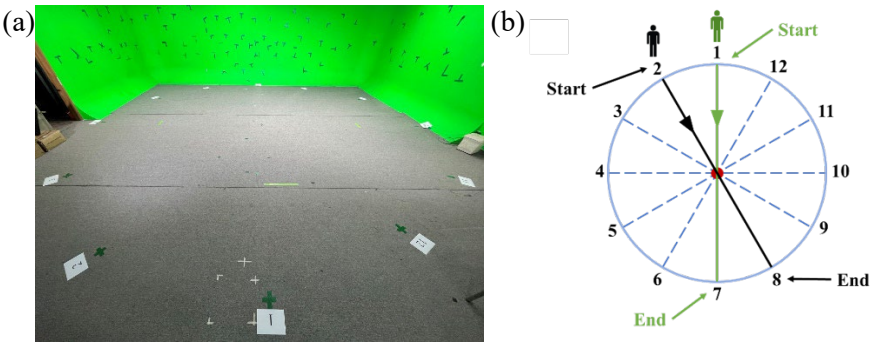

Figure 1: **(a)** The experimental measurement area, **(b)** A diagram of the experimental scene.

As shown in Figure 2, the safety distance seemed to be negatively correlated with the interacting angle. In five different interacting angles (150°, 120°, 90°, 60°, and 30°), the safety distances were 2.31 (±0.75) m, 1.44 (±0.545) m, 1.31 (±0.476) m, 1.14 (±0.361) m, and 0.95 (±0.345) m, respectively. A previous study showed that the safety distance increased with speed [9,10], so pedestrian speed might also be a factor affecting the safety distance. The correlation between the speed product of two pedestrians and their safety distance at five different interaction angles was analyzed, and the absolute value of the Pearson correlation coefficient at five interaction angles is less than 0.2 (Table 1). Within the range of pedestrian speed in this experiment, the safety distance of pedestrians seems to have little relationship with the walking speed of pedestrians.

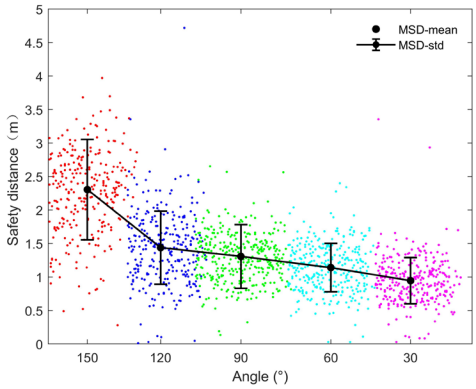

Figure 2: The relationship between the safety distance and the interaction angle.

Table 1: The Pearson correlation coefficient at different interaction angles

Angle	**150°**	**120°**	**90°**	**60°**	**30°**
PCC	0.006	0.115	0.0269	-0.0269	0.0203

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